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BEETLES

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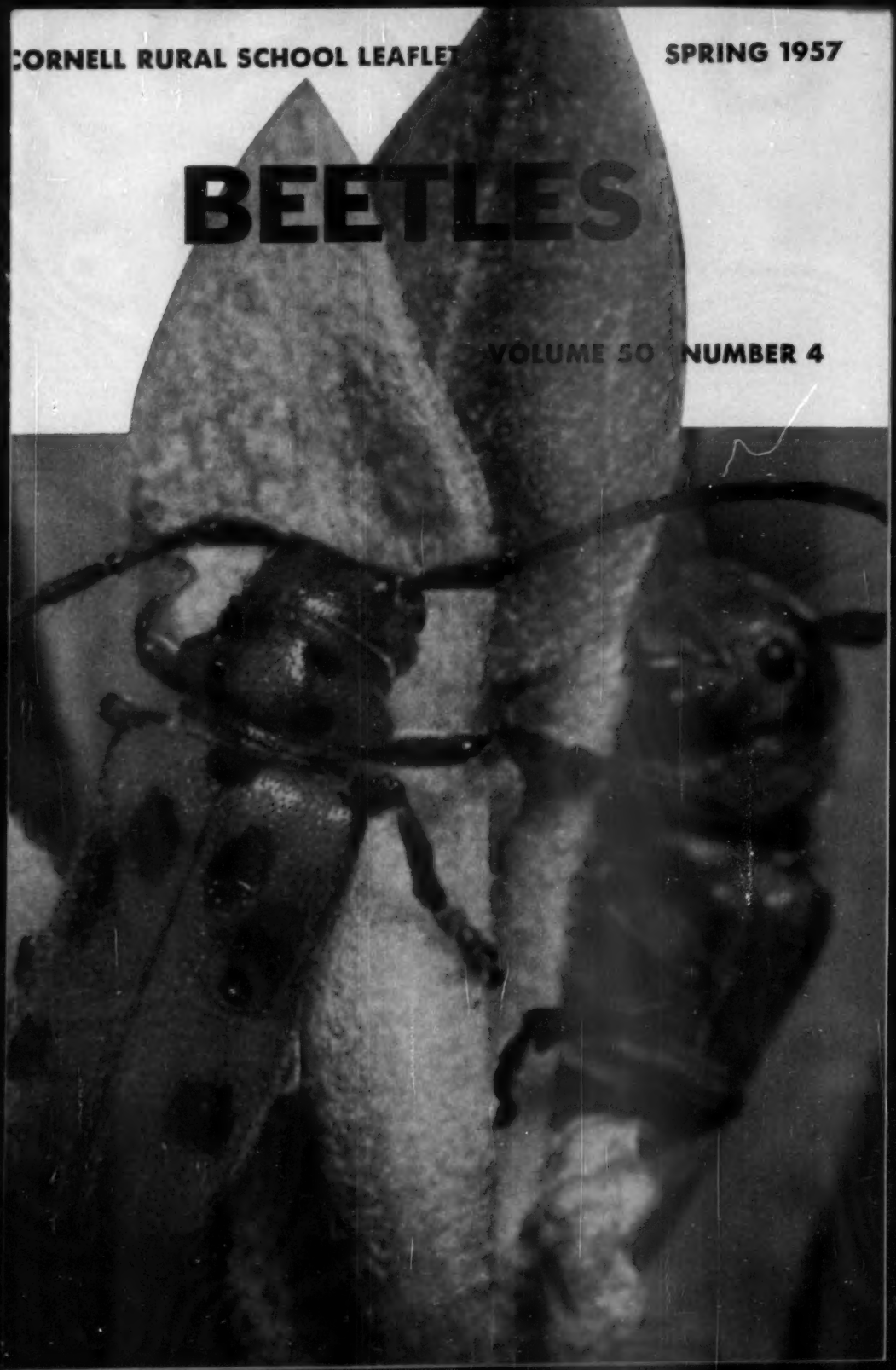

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Beetles

By VERNE N. ROCKCASTLE

If you wrote down the names of all the different kinds of animals in the world, do you know how long it would take? Writing as fast as you could, day and night, without eating or sleeping, it would take more than 100 days. If the names were printed in a book like this, with one name on each line, the book would have more than 6000 pages! That seems like a lot of animals, but just think—one-third of that huge number are just *beetles!*

Some beetles walk, some fly, some swim. Some are small enough to crawl through a needle's eye, and some are as large as a mouse. For their size, they are a hundred times stronger than you are. And such appetites! Some eat tomatoes, others tobacco. Some even eat perfumes. Others can eat poisons. Their ancestors lived millions of years before dinosaurs, and yet today there are more kinds of beetles than there are stars that you can see with your naked eye. So this Leaflet is about the largest, the most diverse, and one of the most interesting groups of animals that ever lived—the beetles.

What Is a Beetle?

It Has Four Wings

You have probably seen and can recognize a "lady-bug":

"Lady-bug, lady-bug, fly away home!
Your house is on fire; your children will burn!"

Try to find a "lady-bug" (it is really a lady-*beetle*, not a bug) to examine as you read this Leaflet. If you cannot find one, any small beetle will do. The beetles

A firefly's wings are just a blur behind the elytra.

that you find around your school or home cannot harm you, so do not be afraid to hold a beetle in your fingers while you examine it. If it struggles, remember that it is just trying to escape from the two-legged giant (you!) who holds it.

The front wings protect

The back of your lady-beetle may resemble a tiny turtle shell. Carefully lift one side of this "shell" and you will discover that it is one of two wing covers that meet in a *straight line* down the middle of the beetle's back. This arrangement of wing covers helps to distinguish the beetles from all other insects that resemble them. These wing covers are called *elytra* (el'-ee-tra; singular, elytron). You might think of them as a sort of hood covering the beetle's flying "engine". When a beetle flies, it lifts its elytra and holds them high out of the way of its flying wings. A beetle in flight is shown on this page. Can you see the elytra? the blur of the flying wings?

The elytra of most beetles are hard and shiny. On most lady-beetles (page 3) and on most tiger beetles (below) they are brilliantly colored and marked with dots or spots. On the whirligig beetle (page 30) that scoots around on the water surface they are shiny black. Some of the beetles that live inside mushrooms and bracket fungi have dull, warty elytra. The elytra of the distinctive "eyed elater" (page 25) are less conspicuous than the "eyes" that may frighten children who find them. Their real eyes, however, are

The tiger beetle is swift, voracious and beautiful.

tiny and well-hidden at the front of the head—far ahead of the "eyes" near the elytra. Because many elytra have beautiful and interesting markings, beetles are fun to collect and display. On page 19 are directions for doing this.

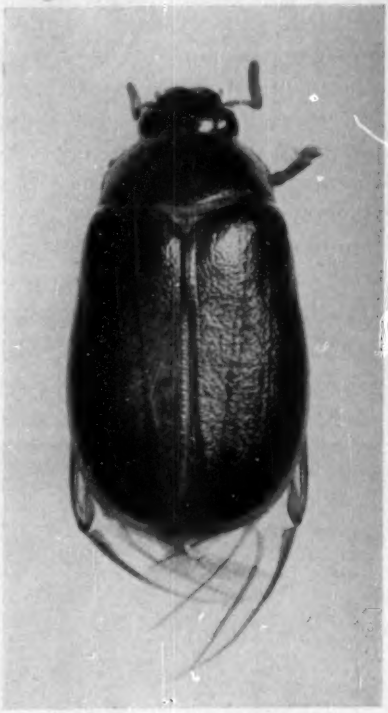
The hind wings fly

In a closed room, let a lady-beetle explore your hand. If you are patient, you may see it wander about your fingers, then quickly lift its elytra and buzz away. Watch how it lands. Does it glide to a smooth stop, or just ker-plunk against the surface? Quickly pick up the beetle and look at its back. Can you see the tips of the flying wings extending beyond the elytra? Beetles often retract their flying wings slowly, dragging the tips around like a hanging shirttail. With the point of a pin, gently lift one of the elytra. Can you see the delicate flying wing folded under the elytron? If you carefully unfold this wing, then release the elytron, you may see the beetle fold the flying wing back under the protective elytron. Can you see where the fold is made? Are the flying wings longer or shorter than the elytra? Are the flying wings brightly colored? Do they make any noise in flight?

Examine several different kinds of beetles (remember that their elytra meet in a straight line) to see if they all have two pairs of wings. Can you find any that do not? Examine some aquatic beetles from the edges of ponds or streams. These can be collected with a kitchen strainer as suggested on page 20. Do these swimming beetles also have two pairs of wings? Do the water beetles use their wings for flying?

Carefully remove the elytra

A May (June) beetle folds its flying wings.



from a dead beetle. This will expose the flying wings. Can you see the veins in the wings? The veins stiffen the wings much as tubing and bracing stiffen an airplane wing. A magnifying glass will help you see the pattern of the veins. Can you see any difference in venation (vein pattern) of two different kinds of beetles? Scientists sometimes use wing venation to help them identify certain winged insects.

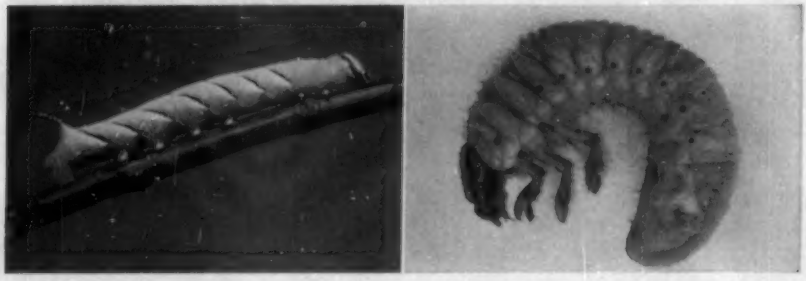
It Has Four Lives

You may have heard that a cat has nine lives. Of course, that is not true. In a sense, beetles, however, do have four "lives". These are not four separate lives, but rather four stages in a single life. Each stage is completely different from the other three. The stage with which you are most familiar is the adult—the stage when the beetle is full grown and has two pairs of wings. Three stages precede the adult, however.

The egg. Beetles lay eggs much as a bird, or a frog, or a fish. They usually lay large numbers of eggs—often too many for all of them to survive. Some eggs never hatch at all. Many of the young beetles that do hatch are eaten by their enemies before they are full grown. Others die from starvation, disease, severe weather, and man's interference (poisons, for example). Unlike most birds, and some fish, that protect their eggs, beetles "lay them and leave them". Their chances for survival are best if the eggs are laid in a protected spot close to the food supply.

The larva. Most beetles' eggs hatch soon after they are laid. Each egg hatches into a tiny worm-like grub called a *larva* (plural, larvae). Unlike caterpillars, which they often resemble, beetle larvae are usually

How can you tell a caterpillar (left) from a beetle larva (right)?



hairless and do not have the stubby legs (prolegs) that support the abdomen of caterpillars. On page 6 is shown the larva of a June beetle compared with the larva of a sphinx moth. How many differences can you see?

The skin of a larva is quite unlike yours. It does not stretch as the larva grows. Rather, like a coat that becomes too small and must be shed, the skin of a larva must be shed (cast) from time to time. This shedding or casting of a skin that has become too tight is called *molting*. Most beetle larvae molt several times before they are full grown. If you are successful in raising beetles (page 18 tells you how) you may find a cast skin from one of your larvae. Smooth it out and examine it with a magnifier. Can you see where the legs, or head, or abdomen were? Cast skins are sometimes used by entomologists (scientists who study insects) in their study of beetles. It is not always possible to find cast skins, however, since some beetle larvae devour their own skins soon after they are shed!

The larvae of beetles are often very destructive to both our crops and manufactured goods. Those that eat our vegetables include the cucumber beetle, the potato beetle, the asparagus beetle, the bean weevil, the bean

The destructive Japanese beetle was imported accidentally about 50 years ago.

beetle, and many others. Japanese beetle larvae (above) attack the roots of plants in our lawns and gardens. Many beetle larvae eat the leaves from our trees and shrubs. Some larvae live in stored grains and cereals. Some might even be called "bookworms", because they eat the dried paper of books and book bindings. Still another beetle, the museum beetle, occasionally lives on the dried insects in insect collections. Can you imagine a collection of dead museum beetles, pinned neatly in rows in a box, being a sort of cafeteria for living museum beetles? If you make a beetle collection like that suggested on page 19, you may be the victim of some museum beetles unless you take precautions against them.

Unfortunately, the larvae of most beetles work unseen. The adults are often blamed for the damage done by the young. Adult beetles do lay the eggs, and frequently they do considerable damage by eating leaves,

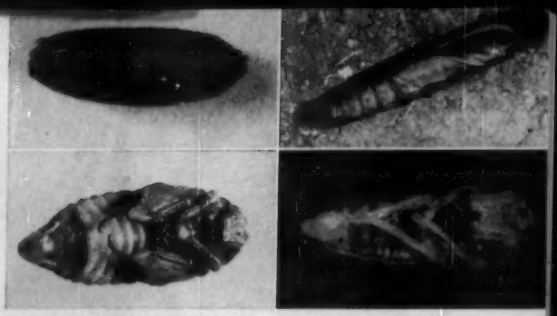
buds, and flowers. It is the larvae, however, that are responsible for most of the damage caused by beetles.

The pupa. When a beetle larva has molted several times and is full-grown, it stops eating and begins its search for a protected spot in the soil, or under a stone, some leaves, or tree bark. After reaching a suitable spot, the larva stops moving, and a remarkable transformation begins. What was a larva now becomes a *pupa* (pew'-pa; plural, pupae). Its skin toughens, and there are visible signs of the antennae, eyes, wings, and legs of the adult beetle. The pupa is helpless. Its only movement is an occasional wiggle – particularly if you should pick it up to examine it. Its only protection from enemies is its tough pupal skin, and the soil or debris that covers it. Inside, the pupa is rapidly changing from a wingless, soft-bodied, often ugly, larva to a fascinating winged creature that bears little resemblance to its earlier stage.

Look for some beetle pupae in your beetle cage (page 18), or out-of-doors under some stones or leaves or tree bark. Can you find the wing cases on the back? the legs in their "plastic boots"? the eyes? the antennae? Keep a record of the changes your beetle larvae make as they pupate and assume their adult form. How many days does it take for a larva to become an adult? (How long is the pupation period?) You can observe this rather easily in flour beetles, whose larvae (called *mealworms*) are sold as reptile food by many large pet shops. Mealworms can be kept in a box or a jar partly filled with oatmeal flakes. There they will feed, molt, pupate, and reach adulthood. Then they will lay eggs and the cycle will begin all over again.

The adult. From one to several weeks, or even months, the pupa lies quietly, although inside it great things are happening. Finally, the pupal skin splits along the back and the fully formed adult, called an imago (i-ma'-go) emerges. The struggle to free itself from the old pupal case is worth seeing. It humps up its back and withdraws its wings from their "packing cases". Then, with much effort, it draws its head and legs free. The beetle has completed a *metamorphosis* (met-a-mor'-fo-sis) or change in form, from a larva without antennae, wings, or compound eyes, to a beautiful adult with all those features and more. Like the flies, and wasps, and butterflies, the adults bear little resemblance to the larvae. In this, they differ from the

grasshoppers and aphids, whose young at hatching resemble the adults, and gradually approach adulthood with each successive molt. Beetles become adults in one step—as if Nature had changed the beetle's clothes in a sort of pupal "dressing-room". Their metamorphosis is a *complete* change.



How does a beetle pupa (lower left) differ from that of a fly (upper left), a moth (upper right) and a wasp (lower right)?

It Has Chewing Mouthparts

Once the adult beetle has emerged from its pupal case it is ready to eat, mate, and lay eggs of a new generation. However, the days, or even weeks, spent in metamorphosis have used up much of the food energy that was stored within the larva befor pupation. First it needs food.

Most insects obtain their food in one of three ways. They can suck juices through a slender tube, as do the butterflies, mosquito, and bugs. They can tear off and chew bits of material as do the grasshoppers and dragonflies. Or they can lap up their food with a spongy tongue as do the houseflies. Which do you do? What insects do you imitate when you sip a milkshake? when you eat a raw carrot or a hotdog? Carefully watch a beetle that is eating. Can you see that beetles, like grasshoppers, are *chewing* insects? They cannot suck plant juices, nor sip the nectar of sweet-smelling blossoms. They must tear or chew their food. Their curved jaws do not have teeth like your own. They are somewhat jagged on their inner surfaces. The projections of one jaw grind against similar projections on the opposite jaw.

There is a big difference between the way beetles chew, and the way you chew. When you chew, how do your jaws work—sideways, or up-and-down? Do both of your jaws or just the bottom one, move? Now watch closely as a beetle chews. Watch the largest beetle you can find. Can you see that its jaws work *sideways*? Do you know of any backboned animal whose jaws move like those of a beetle? Can you find any invertebrate (non-backboned) animal whose jaws work like yours? Jaws that go up-and-down are not found among the "lower" animals, such as beetles.

All beetles chew, but there is much variation in the appear-

ance of their mouthparts. The fierce jaws of the tiger beetle (page 11), are far different from the tiny jaws of a weevil (page 11). The tiger beetle, a metallic blue or green beetle that inhabits sandy roadsides or beaches, waits poised on the ground for some unsuspecting insect to wander close, then pounces on it and tears it to bits with its sickle-shaped jaws. If you wish to capture one of these little insect "dragons" (they make wonderfully interesting pets), you must move stealthily toward it, then pounce on it with your hat, or net, for they are watchful and fast. Once captured, they will try in vain to pierce your skin with their sharp jaws. To a tiger beetle, however, your skin is indeed a sort of armor-plate. So you may watch without fear as it works its jaws from side to side in frustrated ferocity.

In contrast to a tiger beetle's jaws are the tiny ones at the tip of an acorn weevil's long snout (page 11). These jaws can chew a hole through the toughest of acorns although they are so small you can scarcely see them, even with a magnifier. The snout beetle (page 17), likewise, has its mouthparts inserted on an elongated head, giving it a sort of anteater-like appearance. Many persons mistake weevils and snout beetles for bugs, believing that the long snouts are tubes for sucking juices, instead of elongated heads with chewing mouthparts at their tips.

More About Beetles

Their Sense Organs

The antennae. Beetles use their "feelers" or *antennae* (an-ten'-nee; singular, antenna) to help them smell, taste, and feel. Perhaps insects do not feel and taste as you do, but their antennae help them locate food, mates, and perhaps even danger. Exactly how this is done is not known. It may be just the result of the many sensitive hairs and nerves that help detect smells and touches. Antennae are curious structures—ones that you will certainly wish to examine as you learn more about beetles.

The size and shape of antennae vary almost as much as the rest of the body of beetles. On certain beetles, called *longhorn beetles*, the antennae are sometimes longer than the body. On page 11 is shown a longhorn, the pine sawyer. Its larva burrows

The acorn weevil's jaws are almost invisible, but not the tiger beetle's!

deep into pine logs, repeatedly pushing the sawdust to the tunnel entrance as it works. Many little piles of fine sawdust may be found on the ground under a log infested with them, or under the loose bark of a tree or log in which they have tunnelled.

The brilliant red milkweed beetle shown on the cover is a longhorn beetle whose antennae are not so long as those of the pine sawyer, but they are apparently just the thing for locating juicy milkweed plants. The locust-borer (below) whose larva burrows in locust trees, spends the late summer and early autumn rummaging for pollen in the flowers of goldenrod. Its dark brown elytra with their yellow zig-zag markings would make it a colorful addition to your beetle collection.

Many other beetles have thread-like antennae of various lengths. The soldier-beetle (page 12), like the locust-borer, is a goldenrod pollen fan. The *leaf beetles*, such as the Colorado po-

The pine sawyer (left) and the locust borer (right) are typical "longhorns".

A soldier beetle dines on goldenrod.

tato beetle, the elm leaf beetle and the striped cucumber beetle (page 13) have thread-like, but rather short, antennae. Similar antennae are found on the *click beetles,* whose snapping somersaults delight any watcher (see page 25).

Many antennae are straight but some are sharply bent, or *elbowed.* The acorn weevil shown on page 11 has its antennae located half-way between its jaws and its eyes. If these antennae were closer to its mouth, would they help or hinder as the weevil eats food in the center of an acorn? Can you see how its antennae are elbowed? You can see this curious elbowing on most of the weevils. You will probably need a magnifier to see the antennae of the smaller weevils. Are they thread-like? knobbed at their tips? How many other beetles can you find with elbowed antennae?

The *scarab beetles* have bent antennae with a fan-like series of plates at their tips. The June beetle (pages 5 and 14) is an example. Its large, creamy larva is a favorite fish-bait and is often dug from loose soil by fishermen looking for worms. It has powerful jaws and may pinch your skin if you are not careful. The adult is likely to try to bulldoze its way out of your hand. Before it does, though, take a good look at its antennae. Aren't they almost like little antlers? Can you guess why

Three beetles, but a thousand "eyes" watching you!

The potato beetle (left), the elm leaf beetle (center), and the striped cucumber beetle (right) are all destructive.

its antennae are shaped like that? Scientists cannot be sure of the reason, but such antennae are fun to study and compare with those of other beetles.

The eyes. Can you imagine what it would be like to have a hundred, or a thousand eyes, instead of two? Most beetles, like other insects, have two eyes, but these eyes do not have a single lens like yours and mine. Instead, they consist of many tiny hexagonal (6-sided) "cells", each with its own lens, and each staring in a single direction. Such a cluster of visual cells is called a *compound* eye. When highly magnified, it looks like a honey comb.

Scientists have learned much about how a compound eye works. Each 6-sided "cell" is responsible for a tiny bit of the complete picture. Beetles probably have *mosaic* vision, although no one really knows what a beetle sees. You can see one kind of mosaic if you use a magnifier to examine a picture in this Leaflet. Can you see that each picture is composed of many tiny dots or spots? Would a compound eye of many parts, or one of few parts, see a more complete picture? Which do you think a beetle could see better—a moving object, or a stationary one?

On page 12 are shown the eyes of several common beetles. Do any of the eyes appear to be dusty? Beetles have no eyelids to blink as you can, but often use their feet to help wipe off their eyes. You might think of their front feet, their antennae, and the little antenna-like projections around their jaws, as built-in windshield wipers.

The larvae of beetles do not have compound eyes, but have several tiny *simple* eyes, called ocelli (o-sel'-ly; singular, ocellus). These are probably not used for seeing, as are the compound eyes of the adults, but rather for detecting light and dark objects. Living under the soil, or bark, as many beetle lar-

vae do, there is little need for compound eyes. They develop later, when the larvae pupate. As you collect and study beetles, look for those with eyes of interesting shapes or in interesting positions. If you find a red milkweed-beetle, look for four compound eyes instead of two. Its scientific name, *Tetraopes*, means "four eyes." The cover picture will show you what to look for. Can you see an eye above and one below each antenna? Compare this with the eyes of the tiger beetle shown on page 11.

The whirligig beetle or "crazy-bug" (page 30) has eyes that are divided into an upper and a lower half—the top half perhaps for seeing above water, and the bottom half for seeing under water. How many more interesting things can you learn about the eyes of beetles?

Their Legs

A lady-beetle can walk up, down, on top of, and underneath your fingers, without any apparent effort. If you place the beetle in a glass bottle or vial, it will crawl equally well on the bottom and on the top of the glass enclosure. Do you wonder how the beetle does it?

With a magnifier, look carefully at the legs of a lady-beetle. How many legs can you see? Remember that nearly all insects have six legs. Can you see several small joints (the *tarsus*), tipped with tiny hooks or claws near the tips of the legs? These claws help the beetle cling to surfaces such as leaves and stems, or your skin and clothing. But what about walking on smooth surfaces such as glass?

The rose chafer cannot run though its legs are long.

The June (May) beetle: heavy body, weak legs

Just behind the claws you may see some tiny pads. These pads, not present on all beetles, produce a sticky substance that helps the beetle cling to glass. Let your beetle crawl over several different kinds of surface. Watch closely to see whether it uses claws, pads, or both. Try to blow the insect from the surface? Can you do it easily? Sometimes the leg of an insect will even be pulled off before the claws will let go.

Most beetles use their legs for walking or running, but others use them differently. The June beetle's body is too large for its legs to support it easily. The sharp, strong claws of the tarsus, however, help the beetle to cling to roughened surfaces. The rose beetle (page 14) also has strong clinging legs. Can you find some other beetles whose legs are especially fitted for clinging?

The predaceous (devouring) diving beetle shown on this page is a shiny, black, oval beetle that hangs head downward from the water surface when resting or getting air. Its hind legs, fringed with tiny hairs, serve as oars. At the approach of food or danger, the beetle paddles furiously downward from the surface. So voracious are these beetles, that even small minnows and tadpoles fall prey to both the adults

The predaceous diving beetle uses two "oars" to propel itself.

and the larvae. The water scavenger beetle looks a little like the predaceous diving beetle, but it does not often hang head-downward from the surface. Instead, it paddles about submerged plants, or on the bottom, in search of decaying material. The underside of its body often looks silvery from the coating of air it carries as it swims. This air is its breathing supply. Its hind legs, too, are modified as miniature oars to propel it through the water. As you search about the shallows of streams and ponds look for other small beetles whose legs are adapted to their peculiar life in a watery world.

The whirligig beetle (page 30) uses its legs, not to swim, but to cruise or to scoot crazily around on the water surface. Try to catch one in your hands. Can you do

it? Try to catch one with a kitchen strainer. Are you any more successful? These beetles do not normally dive below the surface, but they can do it easily if danger threatens. If you can catch one, look at its legs. Are they equally spaced? Are the legs all the same length? Can you guess why the front ones are constructed the way they are?

As you study various beetles, examine their legs as well as their antennae, eyes and wings. Some beetles, such as the *ground beetles* (page 31) have long, sturdy legs for running. Others have short, stumpy legs that are useful for pushing aside obstacles when burrowing. Some are modified for clinging. Some have adaptations for seizing and holding prey. And, as you know, some are even modified for swimming. Close observation will help you see many more uses for beetle's legs—uses neither you nor I would have guessed.

The Skeleton

When you picked up a June beetle, a rose beetle, or a ground beetle to examine it, were you surprised at the tremendous strength it had? Did you wonder how such a tiny animal could be so strong? Part of the reason is that its skeleton is far different from yours. Your skeleton is on the inside of your body, and your muscles are attached to its bones. But the skeletons of the beetles you have been examining are on the outside! The beetles are actually living inside their own skeletons!

Having a skeleton on the outside has many advantages. One is protection. Can you imagine a beetle being "hospitalized" from a fall off a table or a tree limb? or even a roof-top? Of course not! But what would happen to you if you fell from a tree? Having a tough skeleton on the outside is good protection to the tender parts of the body.

A skeleton serves to hold up an animal, and to provide a firm surface for muscle attachment. Your muscles are connected by ligaments to a slender core of living bone. A beetle's muscles, however, are connected to the non-living armor-like skeleton that covers it. This arrangement may be a great advantage for animals as small as most beetles.

Just as the *exoskeleton* (skeleton-on-the-outside) of a beetle has some advantages, it also has some disadvantages. Can you imagine a beetle trying to grow inside a skeleton that won't stretch? How would you feel if you were buttoned up permanently inside a coat that just fit when you put it on? At first it

This snout beetle resembles a tiny tank with legs

would be quite comfortable, but what would happen as you grew in height and weight? Before beetles are adults, their outer covering is much softer than you usually see it. As they grow, they shed their coverings repeatedly, each time growing a little before they shed the next covering. But when they become adults they have a skeleton that they can't shed, and can't stretch. They spend the remainder of their lives in it. Fortunately for you, your skeleton permits you to keep growing on the outside, adding a little at a time—mostly sideways after you become an adult.

The skeleton of a beetle covers its body, legs, antennae, and eyes. The legs of beetles, like other insects, are merely hollow tubes, inside which are muscles to move them. These tubes do not bend in the middle, so they are constructed in sections. A beetle can move its legs in sections only. These jointed legs (from which the animal group of insects, spiders, and crabs gets its name) are amazingly strong. Yet they are not nearly so agile as your own hands and feet. You can rotate your hand, bend it, twist and snap your fingers, hold a pencil, and do all sort of things that a beetle cannot do.

Small Size

Suppose you were playing a game of hide-and-seek on a large lawn where there were no trees. Could you hide? A beetle could! Or suppose that on the same lawn a blizzard, or rainstorm, or perhaps a catastrophe occurred. Would you be able to find shelter? Most beetles probably could. Because of their small size, and their enormous strength for their size, they are able to squeeze into tiny cracks, under tree bark, or stones, and among the roots of plants. Here they are safe from many of the dangers that face larger animals.

Another advantage of their small size is that for their body

weight they have much more surface area than you have. The reason for this is a little complicated, but perhaps your teacher can show you why it is true. When a beetle falls, or bumps against something hard, it has more protective surface for its size than you have. Some animals larger than you (horses and cows, for example) can be seriously injured by even a short fall. So beetles have a tremendous advantage over you because they are small and have their skeletons on the outside. You, however, have an advantage over the beetles because you are able to move your arms and legs much more freely.

Keeping Live Beetles

To study living beetles at school or home you will need a cage to contain them and their food supply. Two simple cages are shown on this page. One is a glass jar with a piece of netting over the opening. A rubber band or a can ring holds the netting in place. Place some damp leaf mold in the jar to provide moisture and protection.

The other beetle cage can be made from two coffee cans (or a can and a cover) and a piece of wire screen about 17″ by 12″. Roll the screen into a cylinder so that one end fits snugly into a can. Place some loose soil and leaf mold in the can, together with some beetles and food. Cap the open end of the cage with the other can or can cover. You may keep this cage indoors or out-of-doors so long as the soil remains damp (not wet). Perhaps you can even grow a plant in your cage and watch the beetles feed on it.

Good beetle cages need not be elaborate.

A beetle that is easy to study and raise is the mealworm. You can sometimes find them in granaries or in stored cereals, but an easier way to obtain them is to write to a biological supply house for some larvae (you may get an address from your teacher, or from one of the references at the end of this Leaflet). A screened box or jar half-full of oatmeal or bran flakes will provide food and shelter for these

beetles for several weeks. In a few weeks you will see larvae, pupae, and adults in your beetle box. Can you find any larval skins or eggs? You may wish to continue raising mealworms as food for other animals.

By experimenting with milk cartons, oatmeal boxes, cans and cigar boxes, you may devise a cage that is better than those described. You may also find some beetles that are nearly as easy to raise as mealworms. If you are successful in raising beetles, or in constructing a new type of cage, I should like to hear about it.

Making a Beetle Collection

Where To Find the Beetles

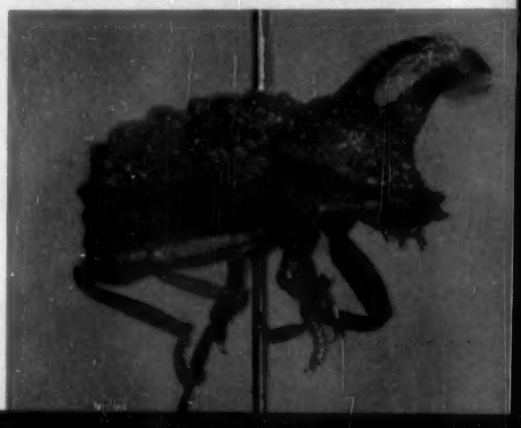
Adult beetles may be found almost anywhere but in the ocean. Look for them on or near plants, where many beetles feed. Some beetles may be collected on flowers, particularly during late summer or early autumn. Examine the blossoms of milkweed, goldenrod, wild carrot, yarrow, and thistle. You will often find beetles probing blossoms for pollen and for other insects. Remember that some beetles are predators—they hunt and devour other insects.

Look for beetles on the leaves and stems of plants. Examine the roses, the trees, the shrubs around your home or school, and the plants in your vegetable garden. There you will often find beetles feeding or hiding.

The bark of trees and logs, even well-rotted logs, may yield interesting beetles. Peel small slabs of bark from decaying logs and search for the beetles that may be hiding or feeding there. Dig into a well-decayed log or stump and see if you can find others. Do not overlook the shelf fungus that may be growing on the side of the stump, or log. Some odd beetles live inside fungi. On this page is shown one of these.

Turn over flat stones in a field, along a stream bank, or near the edge of a woodlot. Many beetles hide or hunt in the cool dampness beneath stones. Others take refuge under leaf litter, under

This queer beetle lives inside fungi. His mate lacks the "antlers".



and behind boards, or in almost any small space that will accommodate them.

Shallow, weedy water is a favorite habitat for some beetles. A few dart about on the surface. Others swim or crawl about submerged weeds, searching for food. One beetle that lives on the fur of the beaver lives both in and out of the water. Another aquatic beetle (the water penny) spends its larval stage clinging to the underside of stones in swift water, its adult stage in the air above.

You can collect beetles best, of course, in summer and early autumn, because most beetles hibernate or die in winter.

How To Collect Them

You already have the essential equipment for beetle collecting: eyes, fingers, and curiosity. *Beetles cannot sting*, so do not be afraid to seek them where they hide. Look in and under things. When you find a beetle, pick it up and examine it carefully. Note its size, color, shape of antennae, legs, eyes, and as many other details as you can. Close observation will help you learn many things about beetles that even books cannot tell you.

If you wish to keep your beetle alive for study, put it in a ventilated jar containing a few old leaves or other debris. In such a jar you may carry several different kinds of beetles at a time. When you wish to add a beetle to your collection, place it in a killing jar such as one described on page 21.

You can pick up most beetles with your fingers. Some, however, are difficult to catch without a net. An inexpensive net can be purchased at a biological supply house, or you can make one from some cheesecloth or mosquito netting, a stout wire coat hanger, and a stick. The illustration on page 21 shows such a net. Cut four pieces of netting material as shown, stitch them together to make a bag, and mount the bag on a wire hoop made from the coathanger. Tape the hoop to a stick to make a long handle.

An umbrella is sometimes useful for catching beetles that hide in shrubbery. Open an umbrella and stand it upside down under the shrubbery. Shake the shrubbery or beat it with a stick. You may be surprised at how many insects fall into the umbrella.

A kitchen strainer makes a good net for aquatic beetles. Draw the strainer through the shallow, weedy water next to the bank. Then lift it up and look carefully for things that move. You will find not only beetles,

but many other aquatic creatures, in your kitchen strainer.

On warm, humid, summer nights many beetles are active. Hang a white sheet inside an open window, arrange a lamp behind it, and you can often attract dozens of beetles (and other insects) without leaving the room. The insects, attracted to the light, fly into the sheet where they can be picked up, examined, and placed in a killing jar.

Your Collection Equipment

To start a beetle collection you should obtain the following inexpensive equipment:

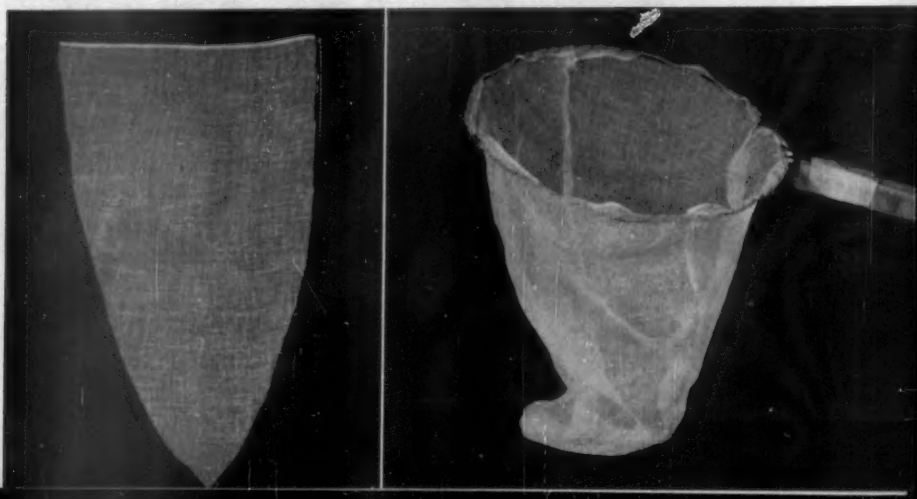
1. A killing jar
2. 100 No. 2 or No. 3 insect pins (or dressmaker's pins)
3. A collection box (a candy box or a cigar box will do.)
4. 100 white paper labels (about ½"×½")

The killing jar. Beetles that are captured for your collection should be killed as quickly and humanely as possible. For this purpose a small jar containing a poison is used. The same poisons that kill insects, however, are often equally poisonous to humans. So it is wise to *treat all killing jars with caution.*

You can make a simple killing jar from a small bottle with a tight stopper, and some rubbing alcohol. Fill the bottle half-full with 3 parts of alcohol and 1 part of water. This mixture will kill beetles quickly, with little change in their appearance. The beetles will dry quickly after they are pinned. Remember that rubbing alcohol is both inflammable and dangerous to drink.

You can also make a "dry" killing jar. Moisten a cotton pad with carbon tetrachloride (often sold as "Carbona"—a cleaning fluid). Place this pad in a jar,

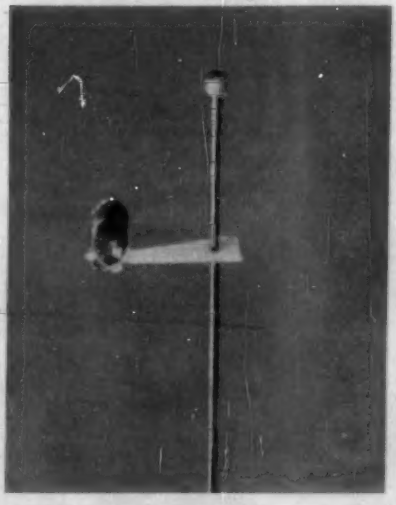
From four pieces of cheesecloth (left) and a coathanger, the net at right was made.



cover it with a tight-fitting piece of blotting paper, and keep the jar closed except when you put in or take out insects. The fumes of carbon tetrachloride are poisonous to beetles (and to humans, too). When all the poison has evaporated from your jar, you can add more to the cotton.

Inexpensive, ready-made killing jars containing deadly sodium or potassium cyanide can be purchased at many supply houses. These jars, however, are very dangerous if kept where small children can reach them. Their fumes are deadly, so keep the jars closed at all times except when putting in or taking out insects. Keeping the jars closed will also help to keep the poison from evaporating. Open your jars only where there is plenty of fresh air.

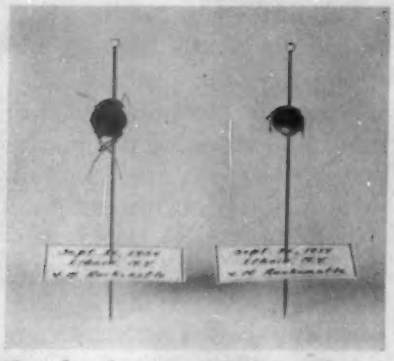
A beetle too small for a pin is glued to a cardboard triangle.



The pins. Commercial insect pins are longer and more slender than ordinary straight pins. They are usually black, have a small rounded head, and come in several diameters. For ordinary work #2 or #3 pins are best. They can be purchased at many supply houses. The biology teacher in your school can probably give you the name and address of the one nearest you.

Dressmakers' pins may also be used, and are much cheaper than insect pins. They are thicker than insect pins, however, so small beetles must be mounted as shown at the left. Push an insect pin through the broad part of a slender cardboard triangle, then glue the beetle to the point of the triangle. Make sure that your beetles face the same way on both the pins and the triangles.

The collection box. Any wooden or sturdy cardboard box about 2" or 3" deep that has a tight-fitting cover will serve as a collection box. Cut a piece of sheet cork or corrugated cardboard (soft insulating board is good if you can find some) to fit the bottom of the box. Over this glue a piece of white paper the same size. This will make a soft, white



Two beetles correctly pinned and labelled with date, place, and collector's name.

bottom into which you can easily stick insect pins. You may decorate the box as you wish.

In one corner of your collection box place a mothball or a tiny cloth container of moth crystals. This will help kill or keep out the tiny museum beetles (dermestids) that sometimes feed on dead insects.

Paper labels. Collecting beetles is fun and worthwhile. It is more worthwhile, however, if you always record the date, locality, and name of the collector. This information may be of real scientific value to you. Put these three bits of information on a tiny label and pin it with the beetle. Above are shown two such labelled beetles. Remember that a beetle on a pin is worth a little, but a beetle and a label on a pin are worth a lot!

Pinning the Beetles

Start your collection with adult beetles. Adults need no special treatment to preserve them. Later you may wish to collect and preserve larvae and pupae. Directions for doing this may be found in some of the books listed at the end of this leaflet or in books in your library.

Always try to pin your beetles when they are freshly killed. Old specimens become brittle, and the legs and antennae frequently break if you handle them. Freshly killed beetles, however, are quite flexible and easy to handle. To pin beetles correctly, insert the pin through the *right elytron* as the picture shows. Leave about ¼ of the pin pro-

The white dot shows where to place the pin.

jecting above the beetle. You can grasp this top part of the pin to remove a beetle from the collection for examination. When the beetle is in place, put the label about halfway between the beetle and the point of the pin. Press the pin carefully into the cork or cardboard bottom of your collection box. The beetle, if it is not bumped or dropped (or eaten by dermestids), will stay for years just as you pinned it. Remember that its skeleton is on the outside!

Arrange your beetles in neat, well-spaced rows. Neatness and orderliness greatly improve the appearance of any collection.

You will probably wish to know the names of the beetles that you collect. You can find some in the books listed at the end of the Leaflet. Do not be discouraged, however, if you cannot identify a beetle. Remember that in New York State there are more than 6000 species—more than all the letters on three full pages of this Leaflet, more than twice the number of stars visible to your naked eye.

Some Beetles You Will Meet

You would think that among such a vast and diverse group of animals there must be some odd characters. There surely are! In fact, each insect has a fascinating character all its own. To describe each, however, would require many volumes. In addition, the lives of many beetles have not been well studied. So a few groups are briefly described in this Leaflet. As you study beetles and learn more about them you may be able to add some new facts to those that scientists already know.

Magic Lanterns

A beetle that all of you have seen at some time or other is the *firefly*. This insect, which is not a fly at all, but a beetle, flies about on warm summer evenings flashing a light at the tip of its abdomen. Its light has puzzled scientists for a long time. The lights that you use are produced by something hot, such as a white-hot wire or a flame. The firefly's light, however, is a cold one, and a most efficient one. In some species only the males produce light. In others, both sexes have lights. In a few, neither the males nor the females produce light. When the larvae are luminous, they are called glow-worms. Perhaps you have read

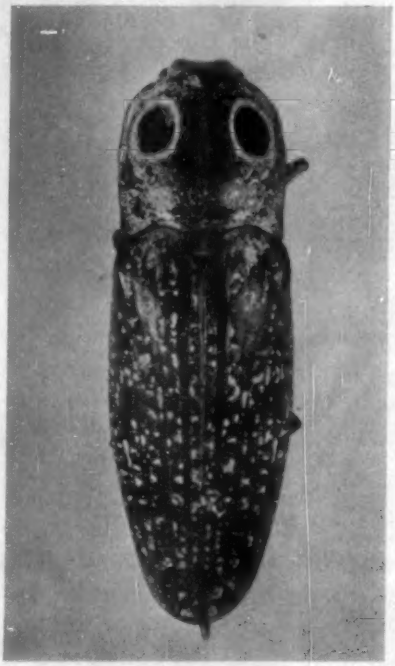
or sung about them.

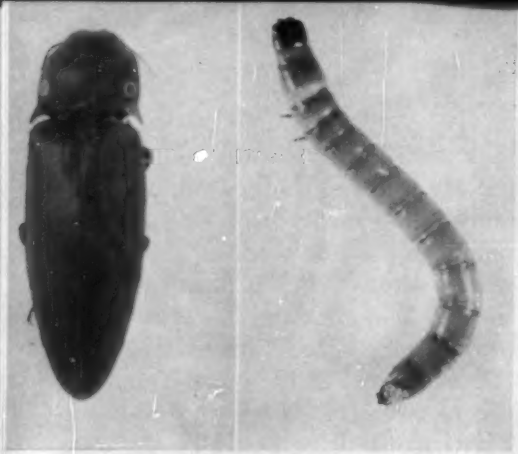
You may wish to experiment with some fireflies on a warm night when the beetles are active. Catch a few and put some in a clear vial or other small bottle. Put the rest in a ventilated, but opaque bottle. Set both bottles outside. Are any fireflies attracted to the clear bottle? to the opaque bottle? From your experiment, do you think the light serves as a signaling device? Count the number of flashes one beetle makes when it is in a warm place. Then put it in the refrigerator or some other cool place to see if temperature has any effect on the rate of blinking. What do you observe? What else can you learn about fireflies?

Acrobats

Click beetles were mentioned earlier in the Leaflet (page 4). They are the adults of *wireworms*, slender round larvae that feed beneath the soil surface. They nibble on the roots of grass, shrubs, and many garden vegetables. The adults are easily recognized by their sleek bodies, and the backward projections at the sides of the thorax as shown in the picture on page 26. (The thorax is the section between the head and abdomen.) Click beetles may be found among the foliage and flowers on which they feed. If one is disturbed, it quickly drops to the ground, often landing on its back. It lies quietly for a few seconds, then with a distinct click it flips into the air. The click-and-flip is repeated until it lands on its feet and can crawl or fly away. You can observe this interesting behavior if you place a click beetle upside down on your hand. Try it with different species of beetles. Do they all click when placed upside-down? Can you find any that do not?

The real eyes of this click beetle are only tiny bumps. Can you find them?





An adult click beetle shows little resemblance to a wireworm.

Wire worms are often very injurious to newly planted corn and other grains. Because they live and feed under the soil they are difficult to control without overturning the soil. Insect-eating birds such as crows, starlings, and meadowlarks sometimes probe among the roots of grasses for these larvae. At times the larvae are eaten by moles and shrews. But often there are too many of the insects for these small mammals to check effectively. You can often turn up wireworms when you hoe or dig around your garden. Perhaps you can even raise a few in a container of soil and plants.

Another acrobat is the *tumblebug*, a beetle with a bug's name. The tumble-bug has a habit of rolling a bit of dung into a ball, then rolling the ball some distance away and burying it. Why it does this is not known, but it may be an attempt to remove its food to a safe distance from other dung-eaters. The beetle may lay eggs in some of the balls it buries. Each egg produces a larvae that eats and grows inside its buried food supply.

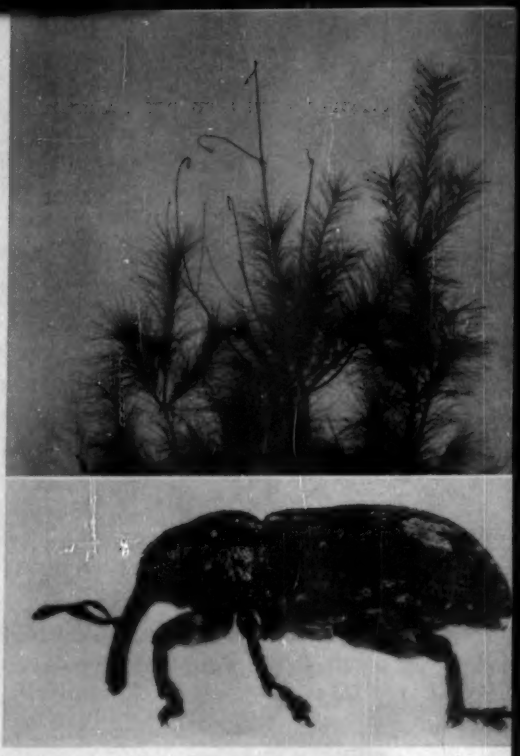
The tumble-bug was sacred to the ancient Egyptians. They often carved images of such *scarab beetles* and set them in rings. You may wish to read more about scarab beetles in some of the books listed on page 32. Remember that the scarab beetle of the Egyptians is only one of a large group including the Japanese beetle (page 7), the rose chafer (page 14), the May beetle (page 14), and others. All are commonly called scarab beetles.

While the tumblebug's hind legs hold a ball of dung, its front legs help propel it.

Long Snouts

You read, on page 10, about the acorn *weevil* and its long snout, tipped with a tiny pair of jaws. This weevil is one of a very large group of beetles. Most of the snout beetles or weevils have the front part of their heads drawn out into long, down-curving projections that resemble beaks. These "snouts" are not for sucking juices, or biting, but only for supporting tiny jaws. Some snouts are very long, while others are quite short. Most weevils are small, often less than ¼" in length. Most of them are of little importance, but a few of them cause untold damage to plants.

At right is shown a young white pine tree that has been damaged by a white pine weevil. This weevil attacks the tips of young trees by feeding and laying eggs in the topmost branches. When the eggs hatch, the growing larvae eat away in the leader (tip) until it is finally killed. When the leader is killed, side branches grow upward to replace the killed portion, and a bushy tree results. Such trees are almost worthless for timber. How many weevil-damaged white pines can you find around your home or school?



Larvae of this destructive weevil killed the tip of this white pine tree.

Other weevils that do enormous damage to plants include the cotton boll weevil, the strawberry weevil, the bean weevil, the plum and apple curculio (weevil), the granary weevil, and the rice weevil. Perhaps you can collect some of these harmful ones as well as some unimportant ones.

Gravediggers

Most *burying beetles* are about ½" long, quite broad, and somewhat flattened. Their flattened shape helps them squeeze under small dead animals, where they remove the soil and thus bury the carcass. Often a pair of them

This rove beetle with its short wings bears little resemblance to other beetles.

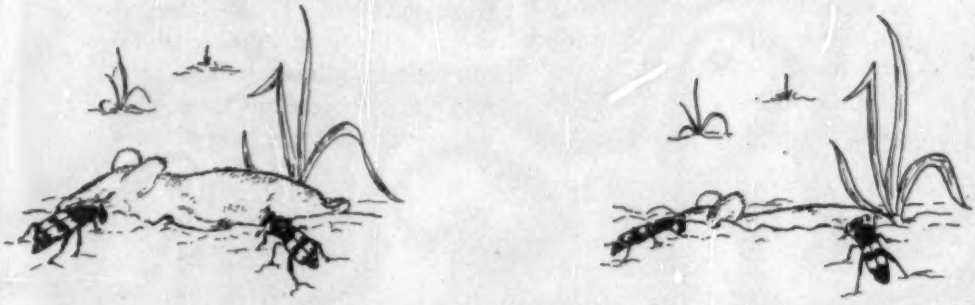
will succeed in completely burying a small dead animal. After the burial is completed, eggs may be laid in the carcass. The larvae that hatch then feed on their buried food supply. Burying beetles feed on decaying animals (carrion) above the ground as often as they do below, however, so they are sometimes simply called *carrion beetles*. The picture below shows two of them at work. You can often collect them by placing decaying meat on the floor of a woods.

Short Wings

In your search for carrion beetles or burying beetles, you are likely to find several medium-to-large beetles whose elytra are noticeably short. They do not cover even half the abdomen. These "clipped-wing" beetles are called *rove beetles*, and are usually found around carrion. At the left is shown a rove beetle. They are true beetles and can be added to your collection to show how variable the wings of beetles can be. Some of the rove beetles are brilliantly colored with red and black, although most of them are rather dull.

Do you think rove beetles can fly? When you disturb one, what does it do with its abdomen? Remember that whatever motions the rove beetles make, no beetle can sting, so do not be frightened by this harmless insect.

A pair of burying beetles remove the soil a little at a time and finally succeed in burying a dead mouse. Later they will feed on the carcass.



Engravers and Tunnelers

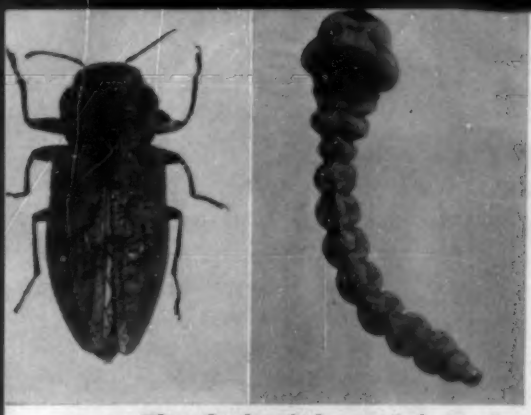
Some beetles are pests because they tunnel in plants, or in products made from plants. Few do any direct damage to animals. One group of tunnelers, the *engraver beetles,* chews out curious connecting tunnels under the bark of living and dead trees. One of them, the elm bark beetle, is a carrier of the destructive Dutch elm disease. It makes tunnels like those shown at right. The adult chews out a broad straight tunnel under the bark of an elm. At intervals along the sides of this broad tunnel eggs are laid. As each egg hatches the larva eats sideways from the main tunnel. Finally it pupates at the end of its burrow. The new generation of adults bores out from these pupation chambers, making tiny shot-holes in the bark. Some species of tunnelers work deep into the wood, leaving tunnels about the size of pencil lead. Such tunnels are sometimes seen in hickory furniture, or in logs that have lain on the ground for some time.

You can probably see for yourself the work of an engraver beetle if you remove a section of bark from a dead or dying tree, particularly an apple or an elm tree. Can you find the galleries left by a tunneler? The central tunnel was made by the parent beetle, the side tunnels by the sons and daughters as they ate their way through the wood. Can you see where some pupation chambers were? Can you find any holes in the bark where the newly formed adults bored their way out? About how many eggs were laid by the parent? (Remember, that each side tunnel represents a larva at work.)

Wood Borers

Another group of beetles bores holes deep in wood, rather than just below the bark. These are the *metallic wood borers,* so-called because their elytra have

Can you find other patterns made by engraver beetles?



The flat-headed wood borer becomes a lustrous beetle.

a bronze metallic luster that few other beetles possess. The larvae of these beetles may be found under the bark of trees and logs, and often in the solid wood beneath. Unlike most beetle larvae they lack legs, and seem to move in their tunnels by twisting their bodies. Their heads are usually flattened and much wider than the rest of the body, giving them the name "flat-headed borer". I once heard a flat-headed borer chewing in a tree trunk at night. It sounded like a person grinding his teeth. I could hear it several feet away from the trunk where the larva was working. The hard, lustrous, bronze-colored elytra of the adults make them beautiful additions to a beetle collection.

Skaters

On page 14 you read about *whirligig beetles*. These are very common on ponds and sluggish streams, or along lake shores. The name "whirligig", is well deserved, for it is dizzying to watch one of them circle crazily on the water surface. If you find a swarm of them, try to keep a single one in sight for a few seconds. Can you do it?

Whirligig beetles feed on bits of dead or decaying matter that spot the surface of quiet water. Throw a dead housefly, or any bit of food that will float, into a swarm of whirligig beetles and watch them dart to it and push it around before them. Can you see the legs that propel them, or do they seem to scoot along with no noticeable leg motion? If you succeed in capturing a whirligig beetle, hold it to your nose and see if you can detect

You must be fast to catch a whirligig beetle.

The black caterpillar hunter is a swift runner.

any odor. What do they resemble? You may wish to keep one or two of these beetles in a home or school aquarium for further study. Keep the aquarium covered because these beetles can fly as well as swim.

The Hunters

As you turn over stones in your search for beetles, you will no doubt see one or more swift-running *ground beetles* that scurry for cover as if they feared the daylight and your prying eyes. Ground beetles are predaceous creatures—they hunt for smaller, weaker animals by night, and rest in the dark dampness under stones by day. Their legs are fitted for running and their jaws for tearing and crushing their soft-bodied prey. In your collection you will surely want to include some of the black, greenish-blue, or even golden ones. Perhaps you will find the large black *caterpillar hunter* (left). Or you may be lucky enough to find a small blue-black *bombardier beetle* (below) that carries in its abdomen a tiny gun that shoots a repellent into the face of its enemies.

These, and many more, you may find as your beetle collection grows. First, you will find beetles when you least expect them. Then, as you learn more

The bombardier beetle carries a tiny, but powerful, weapon in its abdomen.

about beetles and their ways, you will know where to look for them and when to expect them. Collecting beetles is an interesting and exciting hobby that lies at your feet and your fingertips. Later you may wish to extend your study and collecting to include flies, wasps, butterflies, grasshoppers, and other insects.

Useful Books and References

Field Book of Insects by Frank Lutz. G. P. Putnam's Sons, New York, 1935. 484 pages. A complete, illustrated field guide to common insects. For advanced students.

Fieldbook of Nature Activities by William Hillcourt. G. P. Putnam's Sons, New York, 1950. 316 pages. Contains a section on how to make and use collecting equipment and rearing cages.

Firefly by Paul M. Sears. Holiday House, New York, 1956. 38 pages. An entertaining story of the life of Glowworm, a firefly.

4-H Club Insect Manual. U.S.-D.A. Miscellaneous Publication No. 318. Superintendent of Documents, Washington 25, D. C. 63 pages. Brief descriptions of the major insect groups, with directions for their collection and study.

Handbook of the Insect World. Naval Stores Department of Hercules Powder Company, Wilmington, Delaware. 61 pages. A free booklet containing sketches and brief descriptions of many harmful and some helpful insects.

The Insect World by Hilda Harpster. The Viking Press, New York, 1948. 206 pages. Describes beetles in their roles as predators, scavengers, plant eaters. For advanced readers.

Insects by Herbert Zim and Clarence Cottam. Simon and Schuster, New York, 1951. 153 pages. A beginner's guide to the common insects.

The Junior Book of Insects by Edwin Way Teale. E. P. Dutton and Company, New York, 1953. 235 pages. Includes chapters on beetles, beetle hunting, and how to collect, raise, photograph and preserve them.

How to Make an Insect Collection. Ward's Natural Science Establishment, Rochester 9, New York. 32 pages. Directions for collecting, killing, preserving, and rearing insects.

The Insect Guide by Ralph Swain. Doubleday and Company, Inc., New York, 1948. 235 pages. An illustrated field guide to the common insects.

Cooperative Extension Service, New York State College of Agriculture at Cornell University and the U. S. Department of Agriculture cooperating. In furtherance of Acts of Congress May 8, June 30, 1914. M. C. Bond, Director of Extension, Ithaca, New York.